Non-Thermal Effects

Electromagnetic fields too weak to heat up the body had been linked to cancer and other illnesses since the 1960s. The current 'safety' limits are still inadequate to protect workers and the public from these effects. ***Dr. Mae-Wan Ho*** *exposes the bad science at the centre of the controversy.*

The current debate over the health hazards of mobile phones is a continuation of the debate over the health hazards of weak electromagnetic fields in the entire frequency spectrum that began in the 1950s.

The first experiment on the biological effects of electromagnetic fields dates from the end of the nineteenth century when Russian scientist Danilevsky observed effects of radio-frequency fields on a muscle preparation that included the nerve supplying the muscle. Investigations peaked simultaneously with the development of radar between 1930 and 1940, but ended abruptly with World War II [1].

Interest in the subject was rekindled by the discovery that animals and plants failed to thrive and even died in areas exposed to radio waves beyond a certain minimum power density; and also by complaints of workers at radar stations. Research resumed in the 1950s in the former Soviet Union and the United States, as well as in Poland, Italy, and later, Britain.

Public debate over the health hazards of electromagnetic fields began in the United States. In 1973, biologist Robert Becker was approached by the US Navy Commander Paul Tyler to serve on a panel of experts to evaluate some experiments that the Navy had funded. These were in connection with an antenna system the Navy was planning to build in northern Wisconsin that involved grids of buried wires that would extend over thousands of square miles of land. It was to be used for communication with submerged submarines.

Because of the large size of the antenna system, and fears that the non-ionising electromagnetic radiation (NIEMR) it would emit might have impacts on health and the environment, Congress had ordered the Navy to carry out the studies.

The New York Academy of Sciences had sponsored a conference on "Electrically Mediated Growth Mechanisms in Living Systems", and Becker had delivered a brilliant keynote paper that summarised his work up to then, which revealed how electrical fields and currents produced by the body are controlling growth and regeneration. By

the 1960s, Becker had already proposed a theory that an electrical communication system exists within all living things, and also showed that externally applied fields could influence the processes of growth and regeneration.

But Becker was also worried about the undesirable, harmful effects that could come from exposures to external electromagnetic fields that were often orders of magnitude stronger than the fields within the living body. He had taken on a graduate student, Andrew Marino to conduct some studies on mice and rats.

Marino had indeed found that animals exposed to NIEMR suffered adverse effects, when Becker was asked to review the studies that the Navy had funded.

There were seven scientists on the panel reviewing more than 30 studies. Nearly two-thirds of the studies had found biological effects from exposure to NIEMR; and these were in a variety of species, including slime-mould, rats, birds and humans. The upshot was that *all* the panel members thought the proposed antenna was a potential hazard to human health, and they drew up a long list of recommendations and further studies.

In the middle of deliberations, someone pointed out that the Navy's proposed antenna produced NIEMR similar to that produced by high-voltage powerlines, and that in the largest lines carrying 765 000 volts, the strength of the NIEMR might be as much as a million times stronger. That threw the panel into disarray. The discussions became heated, but eventually, the scientists agreed they had to recommend some action: that the Navy should inform a special committee advisory to the President that many Americans might be "at risk" from NIEMR from power lines.

Marino, who told his story in a book published years later [2] had no idea that he and his supervisor were about to be drawn into one of the most acrimonious and lonely battle against the industrial-military complex, and prominent figures in the scientific establishment were to play the key role in victimising him and his supervisor. When it was all over, Becker would lose all grant support, and would have to close his laboratory in Syracuse, New York, after 20 years of pioneering research on the electromagnetic basis of living organisms.

Marino had found that animals exposed to NIEMR of 60Hz from the wall outlet gained less weight and drank less water. The exposed animals also had altered levels of blood proteins and enzymes. That was precisely the same NIEMR that would come from power lines. He had repeated the experiment twice, with the same results.

By then, at least two 765 000 volt lines were being planned, and Marino and Becker were called to give evidence at a powerline hearing which arose from Becker's warnings. Their experiments had confirmed what the Navy's own studies had found. Becker had no doubt that the power line was a potential health risk.

Unfortunately, they were up against Herman Schwan and other scientists who would be defending the industry and their own prestige in the scientific establishment.

Schwan had come to United States from Germany in 1947 under Project Paperclip, a controversial government programme to import German scientists after WWII. He worked for the US Navy until 1950 when he became a professor at the University of Pennsylvania. Schwan had done some research on NIEMR in Germany during the war. After arriving in the US, he began to publish papers saying that 'the laws of physics' showed that the only effects of NIEMR on living things would be through heating or electric shock.

Schwan's writings were bound up with the federal government's concern, which surfaced in the 1950s, over military employees who were reporting various injuries from working around radar – eye injuries, temporary and permanent sterility, internal bleeding and other problems. In response to these complaints, an Air Force surgeon, Colonel George Knauf was asked to determine how much NIEMR was safe. Knauf and Schwan began to work together, with Schwan being the expert on biological effects.

Schwan regarded the stories of non-thermal injuries anecdotal and unreliable. Accordingly, he regarded NIEMR safe if it did not cause heating. What was the maximum level? Schwan 's answer was that the body could handle a certain amount of heat, for example, by sweating, but if the heat reached the point at which the body's regulatory mechanisms broke down, temperature would rise and injury would result. According to his calculations, the 'safe' level would be 10 milliwatts per square centimetre (mW/cm^2).

This level was adopted provisionally by the Department of Defence in 1955, and Knauf got the go-ahead to fund a series of animal experiments to verify Schwan's calculations.

One of the researchers funded was Solomon Michaelson at the University of Rochester, who used beagle dogs as a test animal, and, "in a revolting series of experiments, he literally cooked dogs alive with NIEMR at levels of 50 to 100mW/cm^2" [3]. He recorded burns, fluid oozing from the brain and eyes and body temperatures rising to 106-108F.

Other investigators confirmed Michaelson's work. Gross acute effects had been observed at NIEMR levels only slightly above the safety limit set by Schwan. There was not one instance of an experiment funded by the programme that was conducted at power densities *below* the limit. In other words, non-thermal effects were never investigated.

Schwan was subsequently appointed chair of a committee of the American National Standards Institute (ANSI), whose goal was to set a NIEMR limit or industry. It came as no surprise that ANSI accepted Schwan's position and $10mW/cm^2$ became the "safe" level for such industries as radar and radio and others whose employees would be exposed to electrical equipment.

Over the next twenty years, Schwan published dozens of papers and gave hundreds of lectures, which culminated in his election to the National Academy of Engineering.

What Schwan said in most of his papers was that there were no *known* biological effects of NIEMR below $10mW/cm^2$. There were in fact such reports, particularly from the former Soviet Union, that were never acknowledged by Schwan. Schwan's limit came solely from calculations based on non-biological models, or dead tissues; and all subsequent experiments were simply rationalisations of it, as Marino pointed out.

Michaelson, too, declared that so long as NIEMR levels were below Schwan's limit, they were completely safe. He was especially critical of Soviet scientists who found non-thermal effects below that threshold, and had set safety limits far more stringent that that in the US. He said that the harm done to industry and the military from such stringent limits would outweigh any proposed public-health benefit.

In 1965, the safe exposure limit set for the general public in Czechoslovakia was in the range of microwatts/cm^2, ie, a thousand times smaller than that in the United States [1].

Michaelson's public declarations brought him many important appointments to committees of the National Academy of Sciences, the World Health Organization, the North Atlantic Treaty Organisation, President's Office of Telecommunication Policy, Electric Power Research Institute, etc.

Both Schwan and Michaelson were to be major witnesses on behalf of industry against Marino and Becker.

It turns out that in the mid-1960s, the power industry in the US had already obtained copies of Soviet studies on the biological effects of NIEMR from powerlines. The American Electric Power Company (AEP), one of the largest in the US, commissioned a study by scientists in Johns Hopkins University, the results of which were released in 1967. In a survey involving 11 linemen, two were found with reduced sperm count. In a second study, mice exposed to NIEMR were not harmed, but their offspring, which were not exposed, were stunted. No more follow-up studies were carried out, and request by the John Hopkins team for further funding was turned down.

At an international conference on high-voltage powerlines in Paris in 1972, Soviet engineers announced for the first time to the West that they had performed investigations on the effects of NIEMR on workers and concluded they needed protective clothing. They reported reduced sexual potency and adverse effects on the central nervous system, the heart and circulatory system.

The power industry released translations of the Soviet reports, which were prefaced by Howard Barnes, an engineer for AEP involved in the John Hopkins studies. The Soviet scientists had studied hundreds of linemen, compared to the 11 in the American study. And while the American study involved only physical examinations, the Soviets had performed psychological and neurological tests as well.

But Barnes, in his introduction, invoked an argument that's all too familiar in the current GM debate. He pointed out that there were then 500 000 miles of high-voltage lines in the US, and there wasn't a single report, not one confirmed case, of anyone being killed or made ill by the NIEMR from such lines, so they *must* be safe.

As in the case of GM food, that statement was based on there having been *no studies* on the effects of living near the power lines.

The story that unfolded makes riveting reading. Research findings were suppressed and falsified. Important scientific witnesses failed to turn up or were not contactable. Committees were stacked with industry-friendly scientists.

Marino, Becker and citizens won in the end, at tremendous personal costs to themselves. They prevented one of the two big power lines from being built, and the company that built the first announced it would not build another 765 000 volt line.

Most revealing in the entire episode was the way Schwan defended the indefensible

orthodoxy. He denied all scientific evidence that went against his *a priori* calculation based on the 'known laws of physics' and the utterly false assumption that the living organism was to be regarded as no different from dead or inanimate matter.

As Marino wrote, "..Schwan seemed to view the studies [reporting non-thermal NIEMR effects] as weeds in the garden of known physical laws. Because the know laws did not predict the results of the studies, Schwan's reaction was to denigrate them, rather than assume that there existed unknown laws, or unknown interpretation of known laws.."

Schwan was not alone, the scientific establishment had thrown its weight behind his position until it became untenable. But there has been little change in scientific outlook since.

To this day, the 'safe' exposure limits recommended by the international authority, International Committee for Non-Ionising Radiation (ICNIRP) take no account of non-thermal effects, despite the mounting evidence of health hazards from such effects.

By the 1980s, Marino could already point to the studies reporting NIEMR links to depression and suicides in England, to cancers in both children and adults in Colorado in the United States. Housewives in Oregon who lived in houses with radiant electric heating were subject to increased cancer risk. In Sweden, a correlation was reported between cancer in juveniles and proximity to high-voltage power lines in the Stockholm area. A cluster of rare and lethal ovarian tumours was found in five young girls living near a 69 000 volt line in Florida.

Similar association between NIEMR and cancer was reported in Wichita, Kansas. Men and women living in counties containing cities near Air Force bases were more likely to get cancer than people in similar counties not located near Air Force bases.

Finally, a correlation between electric blankets and miscarriages was also reported.

Successive reports since then, including the latest from the UK National Radiological Protection Board that accepts the links to childhood leukaemia, stops short of drawing any firm conclusions because of the absence of "any proven biological mechanisms".

1. Marha D, Musil J and Tuha H. *Electromagnetic Field and the Life Environment*, San Francisco Press, San Francisco, 1971.
2. Marino A and Ray J. The Electric Wilderness, San Francisco Press, San Francisco, 1986.

3. Marino and Ray, 1986, p. 15.